Pedagogical intent and practice

Ann Heirdsfield
a.heirdsfield@qut.edu.au
Queensland University of Technology

Shelley Dole
s.dole@uq.edu.au
The University of Queensland

Elizabeth Warren
e.warren@mcauley.acu.edu.au
Australian Catholic University

School mathematics textbooks are used in varying ways and to varying degrees by teachers and schools. The presentation of exercises and activities suggests a sequence for instruction and often accompanying teacher notes provide more specific details of how to tailor the lesson to given activities. Some textbooks provide details of investigative tasks to promote conceptual understanding of topics of focus. With teachers taking varied approaches to the use of textbooks, there is great potential for mismatch between the pedagogical intent of the textbook materials and the actual classroom practice that is enacted. In this paper, we report on a study into the use of one textbook series in elementary schools. We present interview data from the textbook authors who describe the pedagogical intent of their textbook series. We combine this with classroom observations of teacher practice to compare textbook pedagogical intent and practice.

One of the most common resources available to teachers of mathematics is a mathematics textbook, predominantly written to align with a specific school year level. Textbooks for the primary school years generally differ in their format to those for the secondary school years. Typically, secondary school mathematics textbooks provide definitions and worked examples, exercises and problems, and answers to these exercises and problems at the back of the book. Chapters are usually organised into specific topics (e.g., Whole numbers and operations, Fractions, Angles) or combined topics (Ratio and fractions, Graphs and coordinates). Primary school textbooks are often organised into daily lessons or weekly units of study within school terms, with specific topics being revisited at later times in the text. Primary mathematics textbooks frequently are student workbooks where students write solutions to given exercises in their textbook. The pages within the textbook are presented in a worksheet format, often including partially worked examples (for students to complete), definitions and diagrams. Not always do primary mathematics textbooks include answers at the back of the book.

By their structure and presentation, both primary and secondary mathematics textbooks suggest a sequence of instruction. The extent to which textbooks impact teachers' enacted classroom practice is complex, influenced by many interrelated factors including teachers' knowledge and beliefs; teachers' experience and confidence in teaching mathematics; and the degree to which the textbook aligns with current curriculum. Textbooks can be regarded as a resource to support planning and teaching of school mathematics. This is particularly important as elementary school teachers are predominantly generalist teachers with little specialist expertise in mathematics education. For many elementary teachers, preparation for teaching mathematics is confined to their undergraduate teacher education program and various ad hoc professional development in-service programs during their career. Many pre-service primary teachers enter teacher preparation programs with negative attitudes towards mathematics and openly express fear and anxiety about teaching mathematics (Dole & Beswick, 2002).

In previous research (Heirdsfield, Warren & Dole, 2008), we investigated the effects of a specific set of textbook materials on teachers' instructional practices, and interactions among the teachers, students and the text materials. The study was

conducted in three elementary schools, across six classrooms. Data sources consisted of classroom observations and teacher interviews. In this paper, we draw upon this research data and combine it with interviews from the textbook authors to compare our findings of enacted curriculum and pedagogical intent of textbook materials.

Overview of Textbook Materials

The textbook materials in our study are generally referred to as the *GO Maths* series and are published by an Australian company called Origo. In the state of Queensland, Australia in which this study was conducted, *GO Maths* was being taken up by many elementary schools, primarily due to the marketing campaign conducted by the textbook series' publishers who are located within the state. The materials comprise four elements: (1) teacher sourcebooks that contain detailed lesson plans of the mathematics to be taught, (2) a student journal (workbook) of tasks and exercises to support lesson outlines in the teacher sourcebook, (3) a computation practice book for each student, extra to the activities in the student journal, and (4) a student check/test book that serves as an assessment of student learning. The materials are entitled Teachers' Sourcebook, Student Journal, *GO Figure* and *GO Check* respectively. The textbook materials are available for all elementary grades from Preparatory to Grade 7).

The teacher sourcebooks are structured into 32 units of work and detail the mathematical background of the topic, the language needed, the materials required for each lesson within the unit, discussion topics and questions, and include step-by-step descriptions of the activities. Lessons within the unit follow a similar structure, comprising *Daily Number Sense*, *Daily Computational Practice*, activity details, and reflection. As outlined in the introduction, the materials have been developed to align the syllabus of the state of Queensland (Mathematics Years 1-10 Syllabus published by the Queensland Studies Authority [QSA], 2004), and each unit of work identifies core learning outcomes and specific core content as stated in the current syllabus (QSA, 2004). As also outlined in the introduction, the program is designed in accordance with current curriculum reform principles, advocating a student-centred approach that emphasises conceptual understanding and fostering of students' thinking and mathematical communication. Mathematical models (e.g., array model for multiplication) and representations (e.g., number line for computational strategies) are used throughout the program to draw attention to mathematical structure and processes. All five strands (Number, Measurement, Chance and Data, Space, and Patterns and Algebra) are addressed in the program.

From their detail and depth of description of activities and teaching approaches, the teacher sourcebooks are considered to offer opportunities for the development of mathematics content knowledge and mathematics pedagogical knowledge. On face value, the materials have the potential to provide a great deal of support in both mathematics content knowledge and mathematics pedagogical knowledge.

The authors' intentions for the program

The authors of the *GO Maths* series participated in a joint interview of approximately 1 hour's duration. The focus of the interview was to ascertain the basic beliefs and values that underpinned the development of the program and to delineate the role each component of the program played. From the interview there

appeared to be three key issues the authors endeavoured to address: (a) the new directions in mathematics requires teachers to engage with new mathematical content that many do not already possess, (b) teaching students good mathematics is a key component of good student learning, and (c) students need to practice and reflect on what they have learnt on a regular basis. These issues became apparent as the authors discussed the Teacher Sourcebook and the Student Journal. A summary of key elements of the interview are presented below. Direct comments from the authors are provided in italics.

Teacher Sourcebooks

According to the authors, aim of these books is to provide content for the teacher, the background to the mathematics as well as a sequence for teaching concepts. They consist of a very descriptive sequence of units and lessons and form the core of the program. Teaching the lesson requires the teacher to read what is in the Sourcebook, teach it and provide opportunities for students to follow up with appropriate written practice. This written practice occurs in the Student Journal. "*There is deliberately less on a page. There had to be less on the page so that students could show their thinking. Mental computation is more about explaining your thinking and the strategies used to find answers."*

Much thought was given to how to sequence the units in the Teacher Sourcebook. The writers stated that before putting pen to paper they spent a substantial amount of time thinking about the sequence of the units, especially in the new content area of mental computation. "*There is a huge amount of new content in the new syllabus. The sequence for teaching mental computation is very different from the sequence that teachers are used to. It is totally changed. We wanted to give them something that showed a sequence of development for this new area."*

In the development of the package, considerable time and thought were given to what constitutes a good lesson. The decision was made that a good lesson consisted of some kind of introductory activity (a discussion around some aspect of number sense), a learning activity that focuses on some of the key concepts in mathematics and requires deep thinking, an activity focusing on practicing this thinking, and an opportunity for reflection at the conclusion of the lesson. "*Teachers don't really think of mathematics like this. We wouldn't have near as an extensive Teacher Sourcebook if teachers were familiar with focusing on developing deep mathematical thinking in their classrooms.*"

The authors expressed some concern about the development of students' number sense and mental computational ability. They felt that students need continual practice to maintain their skills in this area. Hence the focus in the GO Figure book on number sense and the decision to ensure that each lesson in the Teacher Sourcebook commenced with a short activity revisiting mental computation strategies. "*The activities in GO Figure are not a random selection of examples. They are based on specifics and lend themselves to specific strategies. They are sort of self correcting. If they can solve the puzzle at the end then their answers are correct. It is a sequenced book that follows the sequence developed in the Teacher Sourcebook."*

Student Journal

With regard to the student journal, *"One of the complaints is that there is not enough work on a page…. Many teachers are used to saying, "GO to page 26 and let's go through it*." *In this instance the teacher teaches from the page. In some instances little teaching even occurs…The underpinning belief behind this decision was that with a traditional textbook there is not enough teaching going on. It's busy work. The questioning and discussions are often missing when you use a traditional textbook. Schools that are anti-textbooks spend an awful amount of money on photocopying. Photocopy, photocopy. Everything is photocopy. At least with the Student Journal you have a sequence instead of fun activity here and fun activity there with no real connection."*

The authors stated that they had deliberated at length about how to split the 32 units in the Teacher Sourcebooks across the different mathematics areas. Approximately sixty percent of the units were devoted to the number strand. While acknowledging that there is not complete coverage of all the strands they believed that the only way of addressing this issue is to increase the total number of units in the program. The present units on number just cover the requirements of the new syllabus. "*If we cut back on the number of these units we won't be covering number. Our original plan was to have 36 units. But there are only 40 weeks in a school year. Schools asked us to cut back the number of units to 32."* To overcome some of these issues the authors have endeavoured to interweave other strands such as chance and data into the number units. They also reflected on whether the reason that some teachers may be struggling with 'covering' all the units in their classroom time was that in the past they may not have been giving mathematics the attention it required (i.e., that mandated 1 hour a day). *"I wouldn't mind betting that this time gets cut down to 45 minutes a day in many instances."*

Thus the authors believe that the *GO Maths* program not only supports teachers in developing new knowledge and understandings about mathematics but can result in teachers deliberately thinking about the types of activities that they do in their classroom context, activities that are perceived as much more conducive to the development of students' deep awareness and understanding of new mathematical concepts.

Practice

Classroom observations were undertaken in 6 classrooms (1 first grade, 2 second grade, 2 third grade, and 1 fourth grade) in three different schools, with individual interviews conducted with the 6 teachers of the observed classes. For the purposes of this paper, observations of two teachers' classrooms are reported here. The schools represented populations of middle socio-economic status.

The classroom observations were guided by the Observation Scale developed at the University of Wisconsin, Longitudinal Study of Mathematics (see Chávez, 2003). Observed mathematics pedagogy was rated against 9 descriptors in the Observation Scale highlighting students opportunities for making conjectures, building conceptual understanding, making connections, links to real life, explanations of solution strategies, multiple strategies explored, shared understanding, student inquiry guiding lesson flow, and encouragement to reflect upon reasonableness of results (these descriptors are listed in Table 1 below). These 9 descriptors were rated on a three-

point scale (1 = low; 3 = high). Other aspects of the Observation Scale directed observation upon the focus of the lesson (learning and practice of procedures, conceptual understanding, or problem solving) and engagement of student learning in significant mathematics learning. The aims of the interview were to determine teachers' perceptions of the text, instructional decisions relating to the implementation of the materials, how they used the text in the classroom, and what modifications, if any, they incorporated. The comments made by the teachers in the interviews were compared with what was observed in the lessons. The classroom observations enabled viewing of how the curriculum was enacted and, by referring to the intended practice of the textbook series, the interviews enabled teachers' interpretation of the intention of the curriculum materials to be determined.

From analysis of interview and observation data, the picture of practice using the textbook materials became apparent. Although all six teachers used the textbook materials, differences in implementation were observed and reasons for differences became apparent through interview data. In the main, observations mirrored teachers' implementation of the curriculum material.

Case studies of two teachers are presented here to show this connection. The case studies have been selected as these two teachers' pedagogy was scored uniformly, with one teacher scoring high on all 9 descriptors of good mathematics pedagogy and the other teacher scoring low, as summarised in Table 1.

Table 1

Observational Rating on Descriptors of Good Mathematics Pedagogy for Teacher A and Teacher B (3=high, 1=low)

	Teacher A	Teacher B
The lesson provided opportunities for students to make conjectures about mathematical ideas	3	1
The lesson fostered the development of conceptual understanding	3	1
Connections within mathematics were explored in the lesson	3	1
Connections between mathematics and students' daily lives were apparent in the lesson	3	1
Students explained their responses or solution strategies	3	1
Multiple perspectives/strategies were encouraged and valued	3	1
The teacher valued students' statements about mathematics and used them to build discussion or work toward shared understanding for the class	3	1
The teacher used student inquiries as a guide for instructional decisions or as a guide to shape the mathematical content of the lesson	3	1
The teacher encouraged students to reflect on the reasonableness of their responses	3	1

In Teacher A's observed lesson, the lesson focus was on measurement, and specifically mass, where students were exploring the kilogram. The teacher conducted the daily number sense activity as suggested in the Teacher Sourcebook. This was followed by a discussion about one kilogram, with students suggesting things that either weigh more than, less than or about 1 kilogram. During this time and throughout the lesson, the students were encouraged to demonstrate and explain

their thinking and reasoning strategies. During the lesson, the teacher passed around one kilogram weights for students to feel. Open discussion was encouraged.

Student 1: It's not as heavy as a shot put.

Teacher A: No, you put two kilograms together to get a shot put.

Student 2: Can I have a feel of two kilograms?

Teacher A: [Student's name], would you like to share your story about scales?

Student 3: I saw some scales in the supermarket…..

Student 4: We've got scales in our bathroom to weigh us.

Student 5: I was watching the animal show and I saw an anaconda being weighed. It was 103 kg. They had a big hook and put the anaconda in a bag.

The discussion continued for several more minutes, as students described a variety of scales for measuring mass. The teacher used student comments to generate further exploration, discussion and activity. The Student Journal activity required students to order objects according to mass, but the teacher required students to actually write the mass of each of the objects that the students had weighed, thus enhancing the Student Journal task. The students also were required to perform calculations to determine the mass of several objects. The teacher provided each student with laminated number lines (an aid suggested in the Teacher Sourcebook) to support mental calculation for each exercise. The teacher individually corrected each student's work during the lesson and hence managed to have a discussion with each student before the end of the lesson. Throughout the lesson, the students appeared to be challenged, engaged and enthusiastic. In this observation, the teacher was seen to follow the lesson plan closely, but also built on student observations, strategies and conjectures throughout. In the interview, the teacher stated that she liked the program but had identified a number of areas where she felt additional activities and resources were needed which she then added and documented for future reference.

For Teacher B, the lesson focus was connecting division to multiplication using the array model. Although the lesson was introduced by investigating the relationship between multiplication and division, there was no evidence that students understood this relationship throughout lesson. Procedures appeared to be emphasised.

Teacher B: (Writes on board: "4 rows of 10"). How else can you write this? (no answer. (Teacher writes "4 x 10 = 40")

Student: (Student writes" "10 x 4 = 40". Student stops)

Teacher B: (Teacher writes "40 ÷ 4 =")

Student: Ten.

Teacher B: (Teacher writes: "40 ÷ 10 =")

Student: Four.

To rewrite a multiplication problem as a division problem, the students merely guessed where to place numbers. Although the students were provided with blocks to make "rows", may of the students made "groups of" or placed the blocks in a continuous line. In this lesson some modifications were observed, including the provision of a challenge question, although unrelated to the lesson, for early finishers. Overall, it appeared that the students struggled with many of the concepts,

and eventually resorted to guessing answers. For this lesson, the textbook materials suggested a game for consolidation, however many students experienced difficulty with the game. Rather than modify the game in any way, the teacher continued the game, prompting students with the required responses. In her interview, Teacher B stated that in her lessons, she predominantly focused on "what they need to know". She also stated that she encouraged interaction and provided more visual supports and concrete materials than that suggested in the *Teacher Sourcebook*. She reported that she modified the activities to suit the needs of the students. Her focus was on developing their confidence and providing opportunities for the students to experience success.

Comparing Teacher A and Teacher B we see two very different classroom approaches. Teacher A was observed to actively provide opportunities for students to make conjectures about mathematical ideas; to promote conceptual understanding and connections; to link the mathematics to the daily lives of the students and to encourage students to explain their thinking strategies. Teacher A was also seen to take time to listen to students' responses, and to engage students in discussion to expand their thinking about the topic of study. Although clearly following the suggested sequence of the lesson, this teacher was very mindful of students' responses, looking for opportunities to assist students make connections between their own knowledge and new material presented in the lesson. In contrast, Teacher B appeared to have a tendency to 'close down' the lesson, providing minimal classroom discussion and showing little awareness of, or response to, student learning. Student responses that did not follow the focus of the lesson were often dismissed and there was a feeling of the need to complete the lesson sequence as suggested in the Teacher Sourcebook within the lesson timeframe. The teaching approach was very directed.

For both Teacher A and Teacher B, the observed lessons were directly taken from the textbook materials and the suggested sequence was followed. The notable difference was the varying extent to which each teacher followed the lesson 'to the letter' and particularly how they responded to students' answers to their questions. Teacher B's lesson gave the impression that she felt somewhat confined by the textbook and that her focus was on completing the lesson, rather than considering children's thinking. In contrast, Teacher A followed the lesson but took time to capitalise on students' input and to adjust the lesson to match the students' progress.

Discussion

As intended by the authors, the Teacher Sourcebook is based on principles of mathematics reform that encourages students' mathematical thinking and relating mathematics to real world contexts. The case study teachers reported here were seen to follow the lessons as detailed in the Teacher Sourcebook, but observations suggest that learning outcomes for students would be vastly different in the classroom of Teacher A compared with Teacher B. The textbook authors also stated that the structure of the textbook materials was on coherent units of work that spanned the year with individual lessons within each unit providing exemplary lesson sequences to support students' mathematics understanding. Simultaneously, the activities and lesson sequence were designed to promote teachers' own mathematics understanding and thus build mathematics pedagogic knowledge and content knowledge. As stated by Collopy (2003), teachers "may enact lessons in very different ways than how curriculum developers or educational reformers

intended" (p. 228). In this study, all teachers observed and interviewed were predominantly positive about the textbook series, yet their classroom practice varied. Such findings echo previous research (e.g., Collopy, 2003; Remillard, 2000). Clearly, the textbook authors did not intend that activities suggested in the lesson plans should be implemented regardless of student understanding and capacity for success with the activity. Yet, this was the observed practice of Teacher B. While the pedagogical intent of the textbook series reported here was to support open discussions about key mathematical ideas, data suggests that the textbook materials' effect on practice was inconsistent. A key issue is how to communicate what constitutes good practice in a written format through textbook materials.

In this study, teacher and student use of the accompanying (*GO Figure* and *GO Check*) varied from that intended by the textbook authors. The authors intended the exercises in the *GO Figure* books to be based on specific computational strategies. However, when interviewed about this activity book all teachers failed to identify this. All teachers stated that they felt the students enjoyed the *GO Figure* exercises, although predominantly teachers set completion of pages from *GO Figure* as homework with the teacher checking student completion rather than using the activities to generate discussion about strategies.

The *GO Check* activities were identified by teachers as a valuable aspect of the textbook series and they stated that they used students' results to design further teaching. Some teachers, however, stated that they found it difficult to redesign lessons within the units and reteach topics due to the number of units of work within the textbook series. The textbook authors themselves also identified the deliberate way they structured and sequenced the units of work to fit comfortably within a school year, yet teachers still felt that there was little time to revise and revisit after looking at students' results on the *GO Check* activities. This could also attribute to teachers' feelings of being constricted to some degree by the materials and their decisions to omit particular aspects of the lesson.

A consistent issue identified from teacher interviews was their perception that activities in the Student Journal were not comprehensive and provided little time for students to consolidate the key notion of the lesson. As highlighted by the textbook authors, the pages in the Student Journal were deliberately designed to have less text "so that students could show their thinking... and explain their answers." This is an issue in terms of intent and practice. Research shows that such classroom conversations between students and teachers are so that students have opportunities to exhibit their learning. However, this was not identified by the teachers. Teachers did state that the amount on the page in the Student Journal assisted less able students complete the page and therefore feelings of success for these students was achieved. From the conversations with the authors, the authors' focus for the design of the Student Journal was on mathematical knowledge and pedagogy, but the teachers were concerned with student engagement and self-efficacy. In constructing texts, authors need to be explicitly aware of whether the presented tasks and exercises enable students be engaged and will student learning be obvious to the teacher? Thus, it is possible to have a mathematical text that exhibits sound mathematical knowledge and engagement. But, if it is not adopted as it is intended, students might not find the program engaging, and student learning might not be easily measurable or apparent. This not only has implications for the construction of texts but also for how they are marketed and the professional development that occurs to support their implementation in the classroom context.

Concluding Comments

Over the two years of this study, it was seen that while most teachers became more confident using *GO Maths*, some still had concerns that they did not seem to be able to resolve themselves; for instance, how to cater for a wide range of abilities that resulted in their using two different textbooks at different levels simultaneously. Many of the teachers' concerns could be managed through sound pedagogical practices. However, in the short term, professional development might be provided to teachers implementing the program for the first time or early in the implementation stage.

GO Maths exemplifies a substantive change to textbook series for elementary schools in Australia. While many other series purport to align with the new syllabus directions, few explicitly endeavour to focus the learning on two of the main areas of change in the current syllabus (and in most reform syllabuses); that is, a focus on encouraging students' mathematical thinking and relating mathematics to real world context, particularly with regard to arithmetic. Thus the use of *GO Maths* type materials in the schools in this study was a new and novel experience. Not only were these teachers engaging with a new style of mathematics text but also with new ways of thinking about mathematics.

Interestingly, in spite of all these new challenges, these teachers were very positive about the program. In the first year of its implementation in these schools there appeared to be two reasons for this. First, students in these classrooms showed an increased engagement with and motivation to do mathematics. They particularly enjoyed the *GO Figure* component and teachers felt that the layout of the *Student Journal* allowed all students to exhibit some success with mathematics. Second, teachers and parents felt that they could more easily monitor students' progress with explicit exemplars that assisted the conversations between teachers and parents and how well their child was progressing. These findings align with the findings from past research, namely, one of the main factors that encouraged teachers to continue with new reform programs was their students' responses to the program (Collopy, 2003). In the second year, while teachers' comments mirrored many of the comments given by the first time users, they also incorporated reflections about the program itself and their own learning. It seems that familiarity led to a focus on 'the mathematics in the program' with some teachers believing that their knowledge about mathematics had increased over the two year period. The use of *GO Maths* over a two year period supported these teachers own mathematical knowledge development (Remillard, 2000).

From these results it is conjectured that there are three levels that these teacher proceeded through as they used *GO Maths*. The first level focused on the milieu of the classroom; that is, were the students enjoying the activities and learning experiences? If this was the case then they moved to the second level focusing on students' learning – were they learning anything as a result of this engagement? This second level tended to be gauged by the questions they asked and the mathematical thinking that they shared within the classroom contexts. Finally, the focus changed to their own learning and understanding. It is conjectured that only after the first two were reached, that attention turned to what they had learnt as a result of the program. This was measured according to their increased knowledge about mathematics and how to go about teaching mathematics. All of this has implications for implementation strategies for new texts into the school context.

First, the text needs to 'capture' the students. Second, it needs to provide opportunities for students to share this learning and provide ways for teachers (and parents) to easily observe that learning has occurred, and third, the mathematical knowledge and pedagogy exemplified in the text needs to align with appropriate mathematical knowledge and pedagogical practices. Figure 1 illustrates these levels and their interactions.

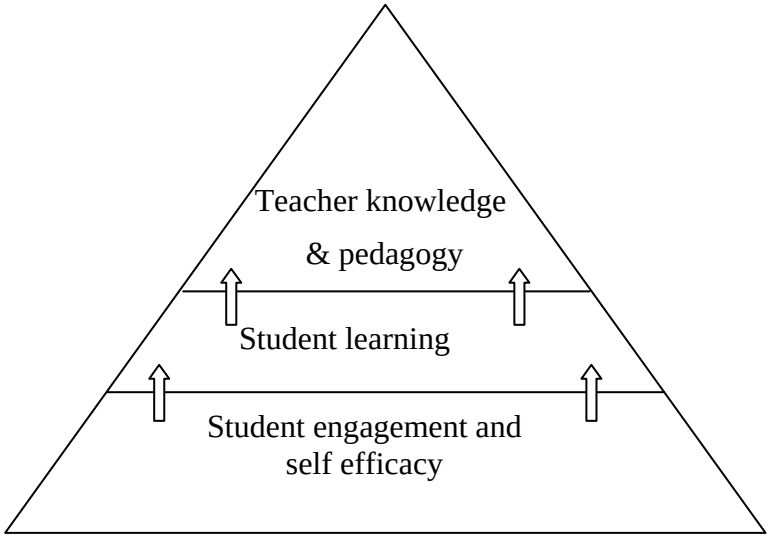

Figure 1. Levels of engagement with text materials.

The way that *GO Maths* was constructed seemed to mirror these levels of engagement; although, at times the intentions of the author seemed to be at odds with why the teachers were positive about the program.

From analysis of the data here, it appeared that effective teachers used the materials in a selective and highly effective manner; ineffective teachers used the materials in such a way that resulted in ineffective practice.

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